NASA'S LONG-RANGE EARTH RESOURCES SURVEY PROGRAM

Address by

Dr. James C. Fletcher
Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Thirteenth Meeting

of the

PANEL ON SCIENCE AND TECHNOLOGY
COMMITTEE ON SCIENCE AND ASTRONAUTICS
U. S. HOUSE OF REPRESENTATIVES

JAN 25 1972

I am very pleased to address the Thirteenth Meeting of this distinguished Panel on a subject that is of great importance to NASA and the country. Remote sensing of our resources and environment is one of the most promising of space technology.

The emphasis that we in NASA place on the applications programs can be measured by our recent establishment of an Office of Applications and the appointment of Mr. Charles W. Mathews as Associate Administrator for Applications. We have taken this step to put together the many NASA activities dealing with the direct benefits to man and society of the new techniques and approaches that have resulted from space research and development. The most significant among these are the Earth Observations Programs -- which include our meteorological and earth resources programs -- and our communications programs. Both of these areas have already spun off viable operational space-based systems. We look forward to many other new operational applications coming from our research and development work such as space manufacturing and space power generation; one of the closest in time, we feel, will be in the area of systematic monitoring and measurement of terrestrial phenomena.

Let me preface my remarks this morning by saying that the title of this address, "NASA's Long-Range Earth Resources Survey Program," is somewhat of a misnomer. First, the program as a whole is far more than just NASA's -- it is the Nation's and to a degree the world's. I want to stress this point: We are talking about a set of related efforts affecting almost every Federal Department, their State and local counterparts, private enterprises, and the man in the street here and abroad.

Secondly, while the program title is "Remote Sensing of Earth Resources," I think we really are talking about a broader framework than the usual sense of the word "resources."

What we are really talking about is obtaining highly useful information and learning to manage it wisely, and in the best interests of the many competing elements of our society, not only the limited natural resources of our planet but the whole global environment. We must manage it as the closed ecological system it is, recognizing its limits and governing ourselves accordingly. This immediately raises the fundamental issues of "management by whom and for whom." One of the problems that I hope we can address in this important session is the need for institutions -- governmental, intergovernmental, and social -- that must evolve at a pace commensurate with the technical opportunities which we see before us.

I am very pleased that we have with us distinguished panels that will be taking up in depth the questions of technical capabilities and requirements, the very real problem of how to manage intelligently the potentially overwhelming volume of data which we have proven we can acquire about our environment, the identification of operational users and uses of earth survey data, and the international implications of this new, still experimental, but very promising area of human activity.

I should also, at the outset, comment on my view of NASA's role in this program. I have already said that it is not uniquely our program in the sense of being a legislated agency responsibility; our job, at this phase of development, is to be the catalyst, to do the experimentation, and to lead the way toward understanding the rational use of new tools for the human good. Of these tools, space and space systems are only one. Space provides an opportunity for near realtime communication between any point on the surface of the globe and any other. Space provides a vantage point from which we can effectively and efficiently observe the surface of the globe -- its dynamic atmospheric envelope, its land masses, and the oceans which make up seven-tenths of its area. We can use spacecraft, therefore, in conjunction with many other kinds of platforms such as aircraft, buoys, balloons, and ground-based stations, to collect a wealth of data in the form of measurements, both direct and inferred.

Note that I say data, not information. As I see it, before data becomes information, it must be in a form to be readily understood and useful in terms of human intelligence. Today, we acquire aerial infrared photographs of the Midwestern corn crop, which by themselves mean nothing. To turn these data into information, these photographs must be painstakingly analyzed by highly trained experimentalists and researchers. Only then do they answer the question, "What does it mean?"

As many of you know, NASA, in cooperation with the Department of Agriculture, has conducted measurements concerning the infestation of Southern corn blight. In that experiment we were able to distinguish several different levels of crop stress. From that information, agriculturalists were able to predict the impact of the disease on the Nation's corn production for the year. This one small example required a very significant effort: The joint university and government team making the analyses worked incredible hours as the data from the high-flying aircraft and ground investigation teams poured in day after day.

This example makes it clear that a key element of any long-range earth survey program must be to develop machine capability that can accept raw data from a variety of sensors (whether air, space, or ground-based), extracting useful information and rejecting that which is not significant. The level of machine capability to which I refer does not exist today. Computers are really only rapid adding machines. What we will need are computers of a different level of sophistication that can "adapt" from their own experience and changing information needs as they digest continuing data inputs.

This work will lead, in turn, to the development of models of the natural world. Such models are just beginning to emerge, but in limited forms and constrained scope. There are steps being taken in the development of a global atmospheric model which is expected to provide weather predictions on the order of two weeks or more into the future. There are hydrological models in being that help us to predict the dynamics of major river systems such as the Mississippi, and these in turn permit us to take action to prevent catastrophic flooding or, conversely, protect us from overreacting to situations where the danger is more apparent than real. There are theoretical models of oceanic circulation, but they are still very incomplete. Yet the oceans, together with solar radiation, are the driving forces that shape our climate and weather and, by extension, the life of us all. In a sense, every farmer maintains a mental model of his acres, on which he predicts results based on decisions regarding what and when to plant, how to control erosion, and what to expect in the way of climate. When we expand the problem to include diverse social or political factors -- that is to say, the often conflicting and competing desires and needs of various segments of society -- we find that modeling is extremely difficult. We have not learned yet how to deal with non-linear feedback to use cybernetic terms of this complexity.

I believe, however, that the experimental program that we are just beginning -- with such projects as the Earth Resources Technology Satellite, the meteorological and environmental satellites, our geodetic and earth measuring systems, and our data relay capabilities -- will offer a compelling promise for intelligent management of our planetary resources. This will force us to make the quantum jumps necessary to create the kinds of interconnected models of natural and human action that will be essential in the near future.

My apparently indiscriminate grouping of classically separate disciplines -- such as oceanography, hydrology, meteorology, agriculture, forestry, cartography, geodesy, and environmental quality -- is actually deliberate. In fact, I foresee a time when these individual disciplines will be regarded as what they really are -- parts of a whole new structure of knowledge, understanding, and action.

Just as occurred in space meteorology and communications, we will undoubtedly initiate our earth resources applications with some rather basic but meaningful and well-understood steps -- perhaps involving improved and more timely land use information in agriculture, more accurate knowledge of the extent of snow and ice cover in hydrology, and means for establishing plankton concentrations in the world's oceans. In addition to beginning a whole new industry -- in aircraft and satellite operations, data processing, sensor development, and so on -- such mainstreams of initial activity and benefits will expand in many directions involving more sophisticated uses such as I am projecting. Ultimately, all of these efforts will become a part of the mainstream in the progress of man in the control of his destiny and that of his planet Earth.

Today, we are beginning to recognize the environmental and technological crises that the abuse of our planet has created. Our attacks on these crises have tended to be highly fractionated: We distinguished sharply between air and water pollution, between mercury in the food chain and radiation hazards, between thermal and noise pollution. Only recently have we begun to recognize the interrelationship -- social, economic and technological -- between all types of pollution and the many diverse and sometimes conflicting corrective actions. Instead of reacting to individual clienteles faced with individual and somewhat limited problems, we must take that great step which lets us look upon all of mankind, present and future, as the clientele we must serve.

The ability to observe and measure the phenomena that affect our everyday life -- and our living -- rapidly, globally, and accurately, is one of the most important products of the space program. In the wise management of all aspects of our planetary home that I am forecasting, I see space as playing a pivotal role. Although we recognize that space systems have inherent limitations, I think we will learn to take the maximum advantage of each of the many techniques which are open to us. And I believe that space systems will provide the critical links that tie together the efficient and systematic implementation of all the observing systems, all of the measuring instruments, and all the sophisticated computer models. Space is also a true driving force in the immediate experimental phase; it is drawing together many disparate communities, many differing viewpoints, by providing a wholly new and unique set of capabilities which must be tested against the needs of those communities. In that testing process, which we are going to begin only in the spring of this year with the launch of ERTS A, some of the hopes for solutions to old nagging problems will be dashed but new approaches that offer even greater promise will be found. After all, if such problems were easily solved, they would have been resolved long ago; it is the hard problems with great potential payoff that are worth working on. But some of these hard problems will turn out to be manageable only because of the unique vantage point of space and through the use of space systems.

We cannot predict today with precision which class of problem will benefit the most from space activities. That is why we expect to have between 200 and 300 separate and distinct investigations in the use of the data that will flow from the ERTS and Skylab earth survey missions.

These use investigations will include participation by Federal, State and local agencies, academic and other institutions both here and abroad and international organizations. The types of investigations cover a broad scope. They include:

- Vegetation surveys, not only to measure crop quantity, quality, and distribution but to use vegetation as an indicator to assess damage produced by highway construction, effectiveness of crop disease control, and the degree of success in reclamation of strip mining areas. These surveys will lead to better management of grazing lands, the detection of breeding locations of destructive or harmful insects such as locusts and mosquitoes, and delineation of coastal wetlands in a truly ecological sense.
- Pollution surveys will deal with coastal waters, estuaries and lakes, haze over major metropolitan areas, and feasibility studies in the measurement of atmospheric particulates on a global scale.
- Measurements of ocean color will be compared with ocean resources in an attempt to aid commercial fishing.

- Repetitive coverage over large areas can provide an opportunity to learn fundamental cause and effect relations governing storm and tidal erosion of barrier islands, the effects of sedimentation and pollution on coastal ecology, and preservation of shoreline assests such as beaches.
- Investigations in land use planning will be conducted at city, county, State and megalopolis levels, not only to obtain up-to-date information on how land is being used today, but to make extrapolations on how future development can best be accomplished.

In addition, investigations will be conducted in a variety of diverse areas such as permafrost and wildlife habitats in Alaska, location of icebergs near the Antarctic continent, and studies of active volcanoes -- to name just a few.

Investigations of these types are included in the broad discipline areas such as Agriculture, Forestry, Geology, Hydrology, Geography and Cartography, as well as Environmental Quality and Oceanography that I have previously mentioned. We are now initiating some of this experimental work. These investigations are directed at specific problems, with particular requirements, and center on well prepared plans for turning the raw data to be obtained from remote sensing platforms into information that can be used by planners and resource managers. As already mentioned, some, but not all, of these will rapidly come to the forefront as major benefits to mankind. Others will move more gradually into such a posture. In my view, the magnitude of their ultimate impact is most probably underestimated by even the most optimistic of us here.

The agencies participating with NASA in the earth resources programs have coordinated their international activities so as to create a positive climate for global research. Representatives from forty countries and sixteen international organizations attended the International Workshop on Earth Resources Survey Systems at the University of Michigan last May. Already some forty-two experimenters from twenty-two countries have been selected on the merits of their proposals to undertake investigations utilizing data from the NASA Earth Resources Technology Satellite project and the Earth Resources Experiment Package on Skylab. Brazil and Mexico have joined NASA in cooperative programs in which remote sensing aircraft help prepare the way for utilization of spacecraft data. Under another cooperative program, Canada is constructing an ERTS data acquisition station in Saskatchewan and a data processing facility in Ottawa. All of these activities are contributing to the full availability and validation of earth resources satellite data on a global basis.

We have a very real opportunity before us in the technological sense. We have an equally great challenge in the social and political sense. Technology in the past has been accused of having out-stripped the institutions it serves and of creating more problems than it solves. I think today, in this field, we are at a point where both technology and society are starting even. But we must move vigorously in the political and social areas to assure that all of society benefits to the maximum extent possible from these technological advances.

I have tried to paint, in very summary terms, a broad-brush picture of where I believe the long-range program of this agency, in concert with many others, can lead us as a Nation and as a society. I would suggest, then, that we take as the theme for the Thirteenth Meeting of the Panel on Science and Technology, not the narrow definitions of remote sensing, but the more profound implications for human good that these techniques, properly managed, can provide us and our progeny.

I would like to leave you with one last thought; we are dealing with a new technology that will revolutionize both human knowledge and human behavior. I do not believe any of us fully realize what ultimately will be at stake in the decisions we make, the actions we take and the policies and precedents we establish. We all can be sure, however, that a great responsibility rests upon us. And I know that this very important Panel meeting will help all of us to discharge wisely that responsibility.

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This example makes it clear that a key element of any long-range earth survey program must be to develop machine capability that can accept raw data from a variety of sensors (whether air, space, or ground-based), extracting useful information and rejecting that which is not significant. The level of machine capability to which I refer does not really exist today. ~~Computers are really only rapid adding machines.~~ What we will need are computers of a different level of sophistication that can "adapt" from their own experience and changing information needs as they digest continuing data inputs.

This work will lead, in turn, to the development of models of the natural world. Such models are just beginning to emerge, but in limited forms and constrained scope. There are steps being taken in the development of a global atmospheric model which is expected to provide weather predictions on the order of two weeks or more into the future. There are hydrological models in being that help us to predict the dynamics of major river systems such as the Mississippi, and these in turn permit us to take action to prevent catastrophic flooding or, conversely, protect us from overreacting to situations where the danger is more apparent than real. There are theoretical models of oceanic circulation, but ~~they~~ these are still very incomplete. Yet the oceans, together with solar radiation, are the driving forces that shape our climate and weather and, by extension, the life of us all. In a sense, every farmer maintains a mental model of his acres, on which he predicts results based on decisions regarding what and when to plant, how to control erosion, and what to expect in the way of climate. of course ~~When we expand the problem to include diverse social or political factors -- that is to say, the often conflicting and competing desires and needs of various segments of society -- we find that modeling is ~~extremely difficult~~ almost impossible. We have not learned yet how to deal with non-linear feedback to use cybernetic terms of this complexity.~~

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Just as occurred in space meteorology and communications, we will undoubtedly initiate our earth resources applications with some rather basic but meaningful and well-understood steps -- perhaps involving improved and more timely land use information in agriculture, more accurate knowledge of the extent of snow and ice cover in hydrology, and means for establishing plankton concentrations in the world's oceans. In addition to beginning a whole new industry -- in aircraft and satellite operations, data processing, sensor development, and so on -- such mainstreams of initial activity and benefits will expand in many directions involving more sophisticated uses ~~such as I am projecting~~. Ultimately, all of these efforts will become a part of the mainstream in the progress of man in the control of his destiny and that of his planet Earth.

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